Konrad-Zuse-Zentrum
für Informationstechnik Berlin

Takustraße 7
D-14195 Berlin-Dahlem
Germany

P. DEUFLHARD, H.-C. HEGE, M. SEEBASS

Progress Towards a Combined MRI / Hyperthermia System

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Peter Deuflhard, Hans-Christian Hege, Martin Seebaß*

Konrad-Zuse-Zentrum für Informationstechnik Berlin (ZIB)
Takustr. 7, 14195 Berlin, Germany
Email: {deuflhard,hege,seebass}@zib.de

Abstract

Regional hyperthermia, a clinical cancer therapy, is the main topic of the Sonderforschungsbereich "Hyperthermia: Scientific Methods and Clinical Applications" at Berlin. In recent years, technological improvements towards a better concentration of heat to the desired target region have been achieved. These include a rather sophisticated integrated software environment for therapy planning and a new hyperthermia applicator. In a next step, a detailed closed loop monitoring of the actual treatment is to be developed. For this purpose the hyperthermia applicator is combined with an MRI system, which will allow to check the positioning of the patients and to measure individual blood perfusion as well as the 3D temperature distribution.

The basic idea is to use temperature measurements directly for an on-line control of the whole treatment. In this intended setting, new fast feedback control algorithms will come into play.

Keywords: *hyperthermia, medical therapy planning, applicator design, interventional MRI*

1. Present Status of Hyperthermia Treatment Planning

Hyperthermia treatment planning has reached some first level of sophistication by the development of HyperPlan from ZIB – for a short survey see [1]. For a convenient use in hospitals the integrated software environment has been carefully designed and implemented (roughly 300.000 lines of code at present) [2]. Steps to be performed within HyperPlan are:

(a) Image acquisition – presently the input is in terms of 2D computer tomograms.
(b) Image segmentation – details of the individual patient's body must be segmented, which is still a challenging task.
(c) From the segmented 2D input a 3D grid patient is automatically generated, using dedicated tools for grid generation, parts of which have been especially designed.
(d) On this grid patient as a so-called coarse grid adaptive multilevel finite element methods are applied to solve both Maxwell's equations (in the radio wave regime) and the bioheat transfer equation (linear and non-linear). Details of these rather sophisticated recent numerical algorithms are given in [3,4].
(e) The compational results are displayed by means of modern visualization tools which also permit a flexible 3D interaction with the virtual models at each stage of the planning process.

The paradigm underlying the treatment planning system is as follows: map the essential features of an individual patient onto a virtual patient (s. Fig. 1), optimize the antenna parameters in the virtual situation, apply the thus obtained optimal parameters in the real situation.